

Vortex Flow Meter “trikon”[®]

Manual



We ask you to thoroughly read the manual and keep it safely.

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1. Safety Information

1.1 Range of Application

The vortex meter is used for rate-of-flow and volume measurement of liquids, gases and steam.

Vortex meters of the "trikon" series are available in the nominal sizes ranging from 15 mm to 300 mm. Depending on the nominal size, they can be used from PN 10 to PN 40. The maximum permissible operating temperature for the medium is 260 °C (450 °C for custom units).

1.2 Hazards

The "trikon" vortex meter has been built in accordance with the latest safety standards. It has been tested and has left our factory in a safety-wise perfect condition. In the case of improper use or when not used as intended by design, hazardous situations can occur.

For this reason note especially the warnings given in the operating instructions.



1.3 Safety

The "trikon" vortex meter complies with the following safety criteria:

- Safety requirements in accordance with EN 61010
- EMC requirements in accordance with EN 50081 Part 1 and 2; EN 50082 Part 1 and 2
- NAMUR recommendation NE 21
- System of protection for housing IP 67 in accordance with EN 60529

In the event of a power failure, the parameter data is saved in an EEPROM.

1.4 Staff for Installation, Commissioning Work and Operation

- Only trained experts authorised by the operator of the system may run the installation work, electrical installation work, commissioning work, maintenance work and operate the system. Such staff must have read, understood and follow the information given in the operating instructions.
- In the case of aggressive media, the resistance of all parts (seals, sensors, casings etc.) in contact with the medium must be clarified first.
- As a rule, the rulings and regulations which apply in your country must be observed.

1.4.1 Factory Settings

The vortex meters are set up in the factory in accordance with the operating conditions specified in your order.

These settings are stated in the enclosed configuration data sheet.

When making any changes to the factory settings, you must take note of Chapter 5 "Configuration / Operation".

1.5 Repairs and Hazardous Materials

The following measures must be taken before you send your vortex meter back to METRA for repair:

- In any case include with the equipment a note with a description of the failure, the application and the chemical and physical properties of the measured medium (for a form, see 14.2).
- The returned equipment has to be clean and dry; remove all residual liquid. Carefully inspect all lining grooves and slots where residual liquid might be found. This is especially important if the medium is detrimental to health (e.g. corrosive, poisonous, carcinogenic or radioactive etc.).
- We must ask you not to return any device about which you are not sure that it is absolutely safe.

Costs that are caused by the possible disposal of the device or personal injuries (e.g. burns), because the unit has not been cleaned carefully, will be borne by the plant operator.

If your vortex meter does not function properly, please contact our customer service:

METRA Energie-Messtechnik GmbH
Am Neuen Rheinhafen 4
67346 Speyer
Tel.: +49 (6232) 657 – 519
Fax: +49 (6232) 657 – 200

1.6 Right of Alterations

METRA Energie-Messtechnik GmbH reserves the right of introducing engineering changes due to improvements without having to provide separate information.

2. Description

The "trikon" vortex meter uses a new state-of-the-art electronic converter. The "trikon" can display counter contents, flows, current output (4-20 mA) or vortex frequency. The flow rate is also indicated with an analog 4-20 mA current loop (according to NAMUR NE 21). The VTX 2 vortex meter is based on two-wire technology and supplied with power via this current loop. With the integrated HART® Interface, long-distance data transmission to a control room or a portable on-site data terminal can be carried out via the same current loop. All the relevant operating or configuration data can be read from or written into the transmitter. Thus the operational mode of the vortex meter can be optimised for the measurement task on site or through a control system.

2.1 Measuring Principle

When a liquid or gaseous with a certain minimum flow velocity meets an obstructive body, the liquid can only follow the contour of this body up to a particular point before it curls up to form a vortex. This happens alternately on either side of the body. The vortices travel downstream forming the "Kármán vortex trail". The frequency of the forming vortices is proportional to the velocity of the flow.

The series "trikon" vortex meter is equipped with a trapezoidal bluff body with a spring plate, which induces a precise and highly repeatable separation of the vortices for both liquid, gaseous media as well as steam.

Both the dimensions of the bluff body and its specially defined separation edge (contour) guarantee a good linearity of the error curve. The vortices separating from the bluff body generate a vortex frequency, thus causing both velocity and pressure alterations, which are detected by a piezoelectric sensor and converted to output signals (4-20 mA or pulses). The conversion is performed by an electronic converter with both auto-adaptive and microprocessor-controlled filtering of the sensor signal.

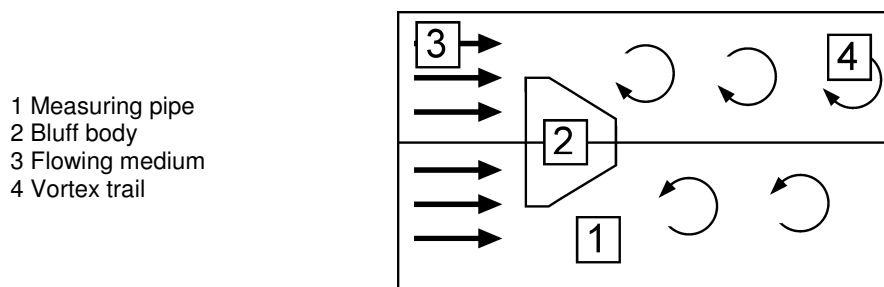


Fig. 1 Principle "Kármán vortex trail"

2.2 System Structure

The vortex meter consists of three basic components:

- The measurement pipe with the bluff body for producing the "Kármán vortex trail".
- The sensor for detection the fluctuating pressure caused by the vortices.
- Electronic converter:
The electronic converter pre-processes and evaluates the meter pulses. An analog 4-20 mA current loop and a digital communication module with HART® protocol are standard features of the device. In addition, a pulse output according to NAMUR (scaled or unscaled) is available. The electronic converter is installed in an industrial-type housing with a screw-down cover. This ensures a high degree of protection against electromagnetic interference and moisture. The electronics is separated from the connection compartment.

2.3 Measured Quantity

The vortex meter measures the volume resp. the volumetric flow

The mean velocity of the flow and the volumetric flow are proportional to the frequency of the vortices produced.

2.4 Measuring Range

Nominal width DN		Gases / Steam in m ³ /h (volume for air)		Liquid in m ³ /h		K factor	
DN	ANSI			min	max	lmp/l	lmp/m ³
15	1/2"	2	25	0.4	8	277	
25	1"	5	130	1	20	57.7	
40	1 1/2"	10	330	2.5	50	15.3	
50	2"	15	560	4	80	7.63	
80	3"	40	1600	6	180	2.22	
100	4"	60	2300	10	300		1010
150	6"	130	5300	20	600		311
200	8"	250	9400	40	1200		138
250	10"	400	16000	80	1800		73
300	12"	500	20000	120	2500		42

Table 1: Measurement ranges; the starting values for gas / steam refer to air (20 °C, 1.013 bar) and those for liquids to water (20 °C).

3. Installation

3.1 General Information

- METRA vortex meters are precision flow meters. Inlet and outlet are covered with caps for protection against foreign bodies. Remove caps shortly before putting the device into operation.
- Observe the operating data on the vortex meter, in the order confirmation and the configuration data sheet. If you want to operate the device with different operating data, you must consult Bopp & Reuther Messtechnik GmbH indicating the factory number.
- The vortex meter may be mounted in any position.
- The vortex meter can be installed in horizontal or vertical pipes.
- The permissible ambient temperature (air temperature around the meter body) must not be exceeded.
- With both high liquid temperatures (e.g. steam) and a horizontal mounting position, it is recommended installing the vortex meter such that the position of the extension pipe with the electronics housing is either up or beside the pipe. Optimal is an installation with a slope of 30-45 °.
- If pipe and meter are thermally insulated, at least half of the extension pipe should be uninsulated.

3.2 Installation Information

Warning

- Before mounting and commissioning the device, carefully read the Operating Instructions and the Declaration of Conformity.
- Before mounting or disassembling the device, depressurize and cool down the system.
- The measuring chamber of the vortex meter must be installed in the pipe in such a way that the IP 67 degree of protection according to IEC 529 is ensured.
- Technical information of the manufacturer referring to the use of the vortex meter in connection with corrosive liquids must be observed.
- The measuring chamber of the vortex meter must be included in the equipotential bonding of the pipe.
- The housing of the vortex meter which accommodates the electronics must not be exposed to sudden temperature changes.



3.3 Fitting the Sensor

- Clean the pipe of foreign bodies before installing the vortex meter. When flushing and purging the pipe, replace the vortex meter with a fitting part.
- Do not remove the caps on the in- and outlet of the vortex meter until you install the device. Ingress of foreign objects must be avoided.
- Observe the arrow on the meter body indicating flow direction.
- Mechanical loads exerted from the pipe onto the meter are not permitted.
- Ensure that the meter body is correctly centered and the gaskets do not project into the free pipe section.
- Centering rings or pipes can be helpful (supplied on request).
- The flat gaskets (not included) must be suitable for the liquid, the maximum operating temperature and the maximum pressure (it is recommended that groove gaskets with a layer and a centering ring be used).
- The inside diameter of the flat gasket must not be smaller than the inside diameter of the meter body.
- The screw bolts (not included) must comply with the specifications according to the operating conditions (flange type, pressure class).
- Long pipes, which are prone to vibration, must be supported or fixed in the up- and downstream pipe section.
- Carefully check the system for tightness after completing the installation.

3.3.1. Up- and Downstream Pipe Sections

A fully present, turbulent and undisturbed velocity profile in the upstream pipe section is a prerequisite for a valid measurement.

The minimum lengths are the following:

10 x nominal size for the upstream pipe section

5 x nominal size for the downstream pipe section

In view of the most commonly encountered installation mistakes, following drawings show the minimum upstream and downstream pipe sections which are required:

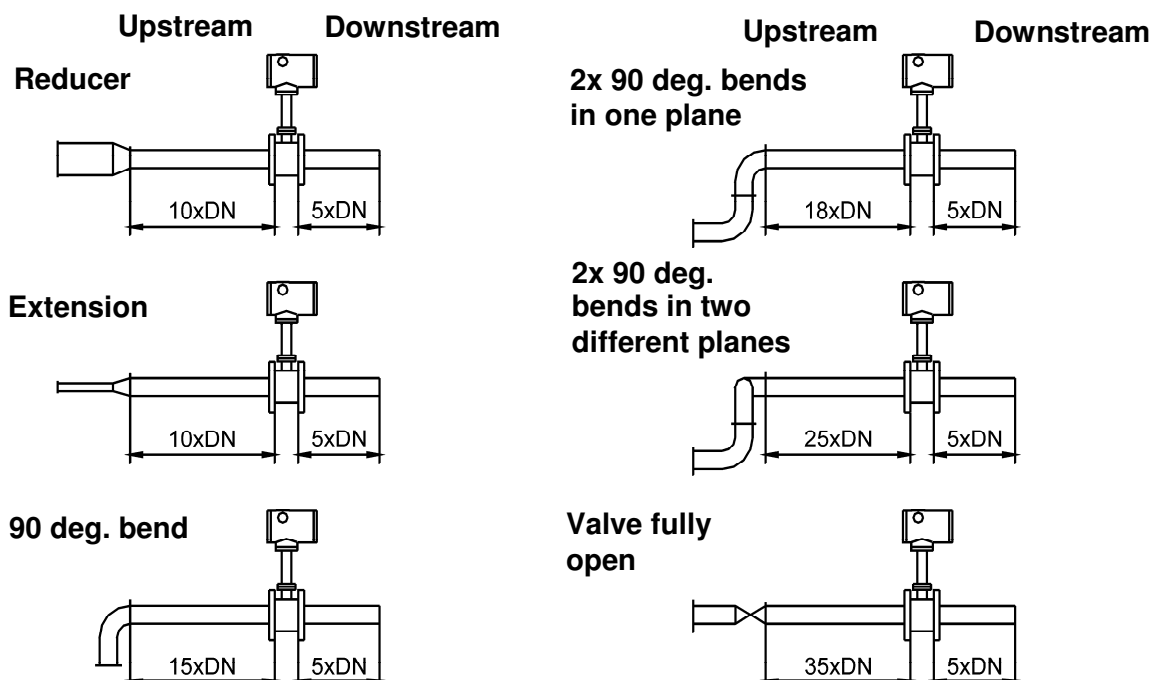


Fig. 2 Upstream and downstream pipe sections

3.3.1.1 Flow Straighteners

The installation of flow straighteners may reduce the influence of disturbances and the length of the required upstream pipe section. If the measurement has to be very precise, the upstream pipe section with a built-in flow straightener must be taken into account in the calibration process.

3.3.2.1 Pressure and Temperature Compensation

If pressure and/or temperature measurements are planned, the respective measurement device must be installed in the downstream pipe section. The pressure measurement device must be installed 3 x nominal size and the temperature measurement device 5 x nominal size downstream from the vortex meter.

3.4 Turning the Electronics Housing / Turning the Up-Front Display

At the transition from the sensor housing to the spacing pipe, the set screw with the 2 mm hex. socket must be loosened. Then the housing may be turned to the desired position. Finally the set screw is arrested once more.

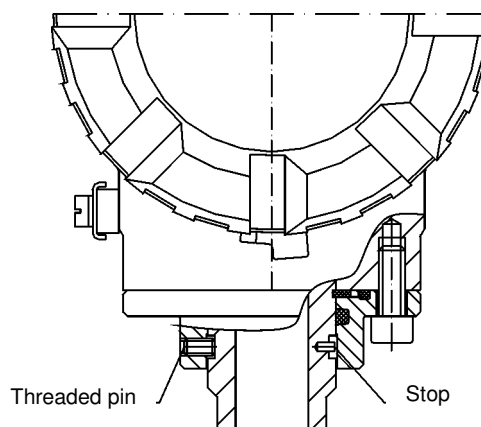


Fig. 3 Turning the electronics housing

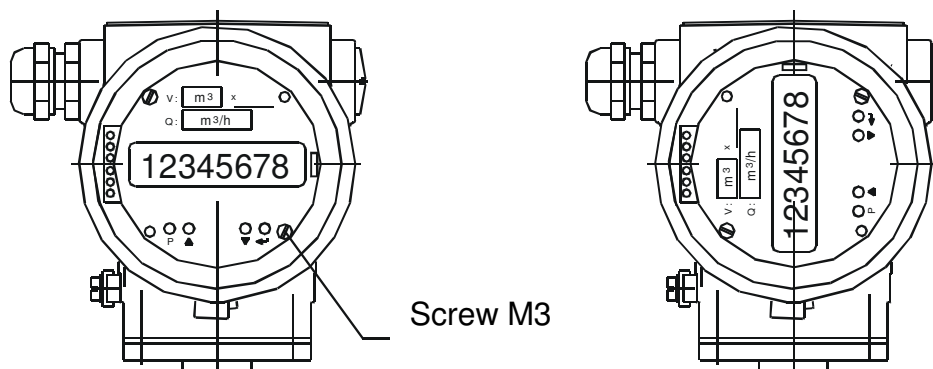


Fig. 4 Up-front display / turning the display

The up-front display may be turned in 90 degree increments.

For this:

1. Unscrew the dial plate (loosen two M3 screws)
2. Turn the two size 5 hex. studs out
3. Now the operating unit with the display may be carefully pulled out of the connector and inserted again in the desired 90 degree position.
4. Fit the hex. studs and the dial plate once more.

4. Electrical Connections

The electrical connections are located behind the cover on the short side of the housing.

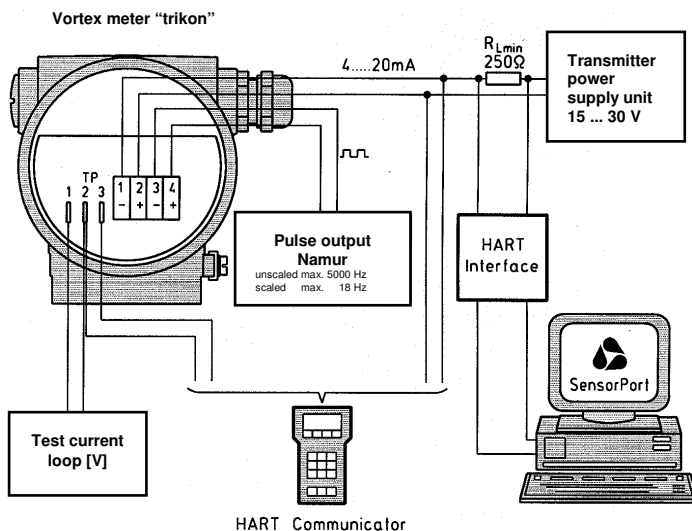
To operate the "trikon", a two-wire link (terminals 1+2) will do. This two-wire link has three functions:

- Transmission of the 4-20 mA analog signal corresponding to the flow and the pre-set range limits.
- Provision of the auxiliary energy for the "trikon".
- Transmission of the digital HART communication signal.

In addition two further terminals (terminals 3 and 4) are available for the pulse output in accordance with NAMUR.

Located on the connection pcb. are three tabs (TP) for servicing.

- I. Connection at TP 1-2
Voltage measurement 40-200mV corresponding to 4-20mA to check the analog signal
- II. Connection at TP 2-3
Communication via HART handheld terminal or HART interface (note explosion hazard regulations!)



Caution

For HART communication a minimum load of 250Ω is required!

Fig. 5 Connection options

4.1 Connecting the "trikon"

Power supply

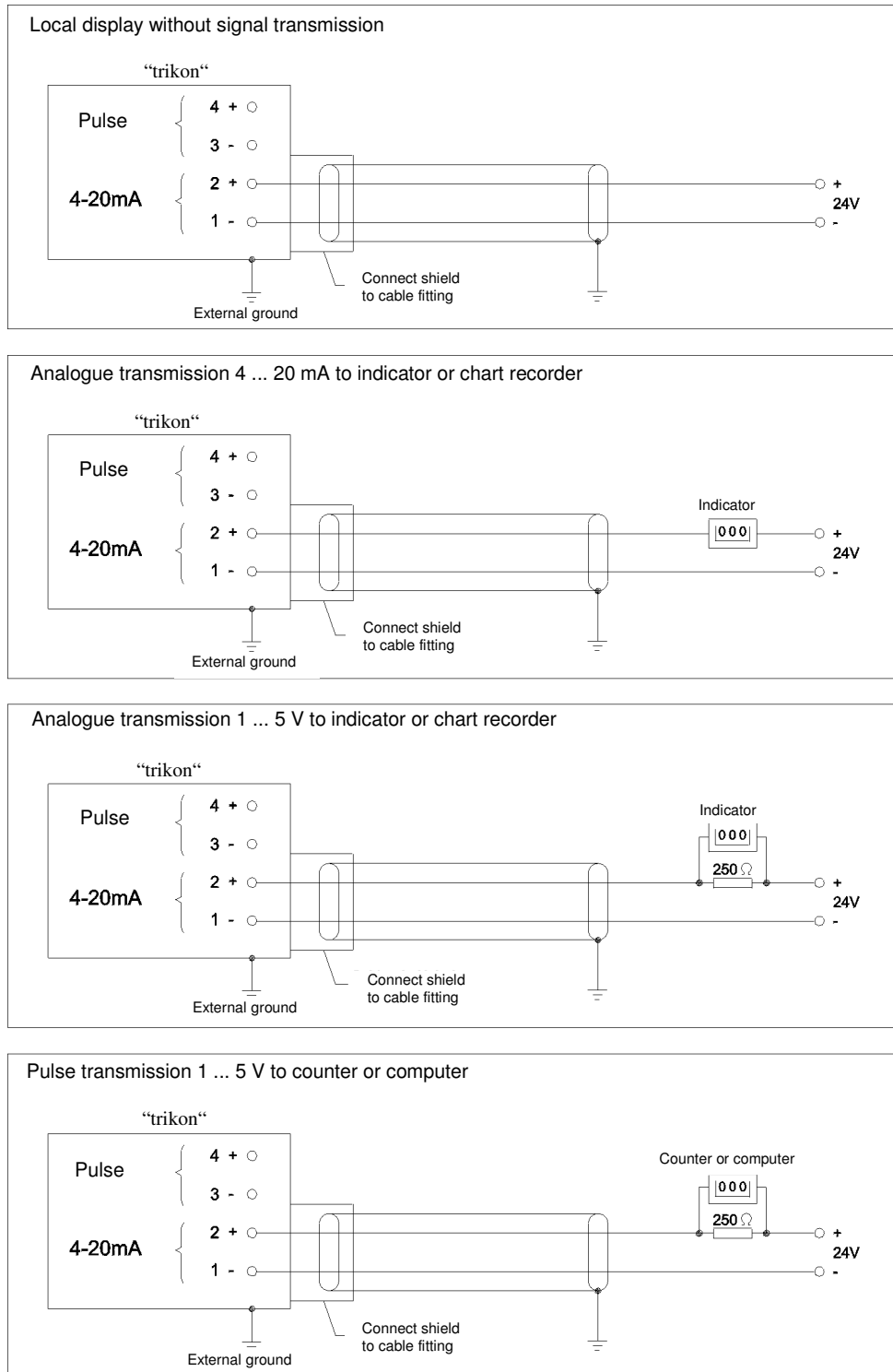
The power supply voltage range is 14 - 30 V DC, and 30 V DC must not be exceeded.

Cable fitting	:	M20 x 1.5
Cable diameter	:	6 to 12 mm
Terminals	:	GKDS Ex
Wire cross section	:	4 mm ² rigid
Wire cross section	:	2.5 mm ² flexible

In order to comply with the stringent EMC requirements, shielded connecting cables must be used. The shield must be connected at both sides. A requirement for this is an effective and trouble-free equipotential bonding within the system.

4.2 Examples of Connections

4.2.1 Application within Non-Explosion Hazard Areas



4.3 Load

As to the permissible load, several parameters need to be considered.

In order to ensure reliable HART® communication, the limits for the minimum load of $R_L \geq 250 \Omega$ must be observed.

Maximum Load:

The maximum load depends on the power supply voltage. The following relationship applies:

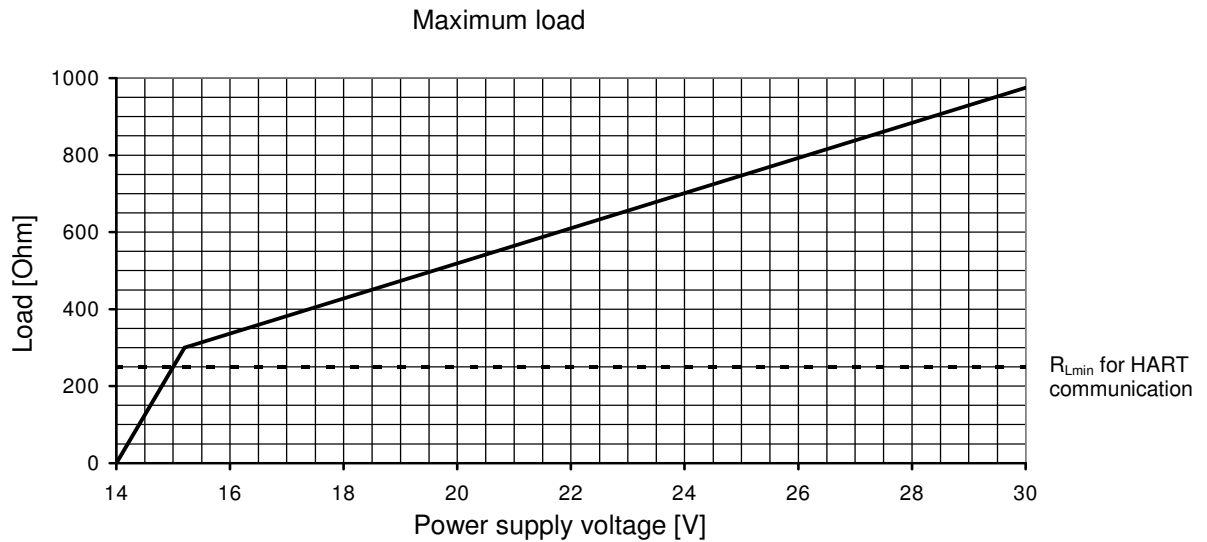


Fig. 6 Load

For $U_B < 15.2V$:

$$R = (U_B - 14V) / 0.004A$$

For $U_B \geq 15.2V$:

$$R = (U_B - 8.5V) / 0.022A$$

The resistances are stated in Ω .

4.4 Max. Electrical Specifications Relevant to Safety in Accordance with the Declaration of Conformity

Two-wire power supply and signal circuit (4 –20 mA current loop), terminals 1/2

Voltage	$U_i = 30 \text{ V DC}$
Current	$I_i = 110 \text{ mA}$
Power	$P_i = 825 \text{ mW}$

Effective internal capacitance	$C_i \leq 11 \text{ nF}$
Effective internal inductance	$L_i \leq 4 \text{ }\mu\text{H}$

Two-wire signal circuit (NAMUR pulses)
(frequency signal output acc. to NAMUR),
terminals 3/4

Voltage	$U_i = 20 \text{ V DC}$
Current	$I_i = 50 \text{ mA}$
Power	$P_i = 160 \text{ mW}$

Effective internal capacitance	$C_i \leq 11 \text{ nF}$
Effective internal inductance	$L_i \leq 4 \text{ }\mu\text{H}$

4.5 HART® Connection

For HART® communication there are different connection options. In any case it is required that the loop resistance remains below the values given in Chapter 4.3. The HART® interface may be connected at pads TP 2 and TP3 in the compartment for the terminals with the cover removed. If the HART® interface is to be used at a different point within the current loop, then it may be connected as shown in Fig. 5.

In the example given in Fig. 1, the connections of the HART® communicator may be replaced with those of the PC or Laptop.

5. Configuration / Operation

5.1 General

The following options are available for configuring the transmitter.

1. HART® communication through PACTware
2. HART® communication through a handheld terminal
3. Up front operation through the keys and display of the operating unit

5.2 Configuring Using the Keys on the Operating Unit

5.2.1 Operation

The instrument can be operated up front through the four keys on the operating unit. For this the cover needs to be removed:

The following functions have been assigned to the keys:

„P“	Programming	Switches the programming mode on, sets decimal point.
„▲“	Plus	Increment
„▼“	Minus	Decrement
„↵“	Enter	Selects the next digit, carries a value over

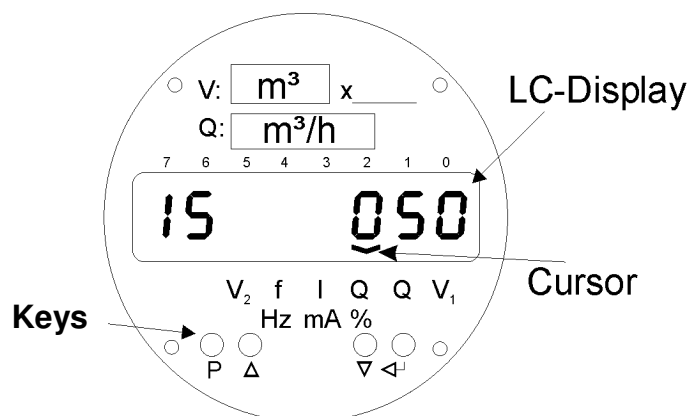


Fig. 7: Operating unit

5.2.2 Up Front Display

On the display all variables and parameter settings may be displayed. The process variables are marked by the position of the cursor, the parameters and service data by a two-digit channel number.

When in the operating mode (roll mode) the flow and count are displayed in alternating fashion. By operating the plus or the minus key, the operator may switch over the display to indicate the desired channel.

After about 5 minutes the selected channel changes back automatically to the roll mode where count and flow are displayed.

Keeping the plus key depressed for 3 seconds will invoke the roll mode immediately.

5.2.3 Access Levels

When operating the instrument via the keys, there are three access levels which must be considered.

In channel "a" the desired access level can be enabled at digit 0 (see also table "Functions switches").

- Display level (operating mode) A/0
All configuration and measurement data can be displayed, writing can only be done through channel a.
- User level (programming mode) A/1
In addition the default settings for the vortex meter can be configured. On this level, operation of the function switches can be changed.
- Service level (programming mode) A/2
All coefficients and alignment parameters can be configured.

5.2.4 Examples

i General note: After each change to the settings the instrument should be reset (power on reset or reset through function switch B2) so as to check the newly entered resp. changed values through invoking the corresponding channel number.

Plus key (▲)

To select a channel and to change the content of the channel – in the positive direction.

Example:



Minus key (▼)

To select a channel and to change the content of the channel – in the negative direction.

Example:



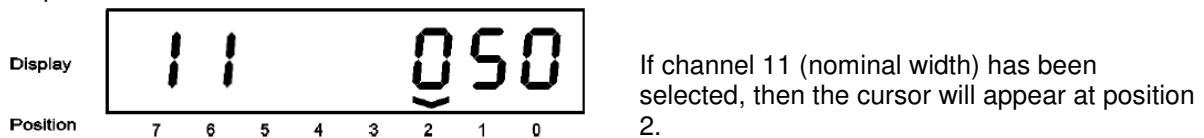
Programming key (P)

This key has two functions:

- Change of channel content

The desired channel is selected through the plus or the minus key. Operating the programming key enables the channel so that its content may be changed. The cursor will be displayed.

Example:



- Setting the position for the decimal point.

If the desired channel has been selected and if the programming key has been operated so that the cursor is visible, now a decimal point may be set at the position of the cursor. Pressing the programming key once more deletes the decimal point.

Example:



For the following channels floating point entries are provided for:

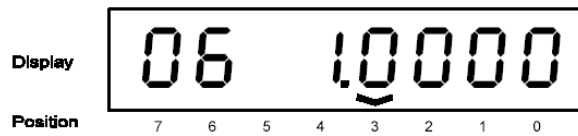
- | | |
|---------------------|------------------|
| - Max. flow | = Channel No. 6 |
| - Min. flow | = Channel No. 7 |
| - k factor | = Channel No. 8 |
| - Pulse factor | = Channel No. 9 |
| - Operating density | = Channel No. 13 |

Enter key (↵)

To move the entry position (the cursor moves from left to right) and for taking over the current value (cursor is no longer displayed)

Moreover, with the enter key it is possible to reset the status information in channel 17.

Example:



In order to activate channel 6, the enter key needs to be operated four times so that the cursor moves from position 4 to the right. Pressing the enter key once more will shift the cursor out of the display to the right and channel 6 with the current content (1.0000) is activated.

5.2.4 Channel Overview

Channel Code Table

Channel	Function	Default			Order of entries Keys	Level a/o
		Digits	Value	Unit		
Process variables	(0) Total totalizer	8	V1	m ³		-
	(1) Flow rate	8	Q	m ³ /h		-
	(2) Percentage display	4	Q/Qmax	%		-
	(3) Current display	4	I	mA		-
	(4) Vortex frequency	8	f	Hz		-
	(5) Resettable counter	8	V2	m ³		-
Basic settings	6 Upper range value	5	Qmax	m ³ /h		1
	7 Lower range value	5	Qmin	m ³ /h		1
	8 k factor	5	K	Imp/l o. Imp/m ³		1
	9 Pulse value factor	3	1	-		1
	10 Unit selection	2	(5)	m ³ /h		1
	11 Nominal size	3	DN	(mm)	3	1
	12 Medium	1	Liquid/gas/steam		1	1
	13 Minimum operating density	5	ρ	kg/m ³	2	1
	14 Current damping	3	3	s		1
	15 Current simulation	3	4.0	mA		1
	16 2-wire current loop	1	Analog/pulses	-		1
	17 Status information	3	000	-		-
	a Function switch a	7	0001110	-		0
	b Function switch b	7	0010010	-		1
	c Function switch c	7	0000000	-		1
	d Function switch d	7	0141100	-		1
Special settings	20 Capacitance selection	1	0-5	-		2
	21 Resistance selection	2	0-15	-		2
	22 Amplifier level	1	4	-		2
	23 Intermediate filter fu	1	0-3	-		2
	24 Intermediate filter fo	1	0-3	-		2
	25 Output filter fu	2	0-15	-		2
	26 Output filter fo	2	0-15	-		2
	27 Lower switching voltage	3	0.70	V		2
	28 Upper switching voltage	3	3.30	V		2
	29 Flow rate factor	5	1	-		2
	30 Volume factor	5	1	-		2
	31 Pulse ratio factor	5	1	-		2
	32 Current calibration 4mA	5	400	-		Y
	33 Current calibration 20mA	5	14000	-		Y
	34 Sensor comparator	3	127	-		Y
	35 Quartz frequency	5	460.00	kHz		Y
Service values	36 Amplitude RQ	3	approx. 2.5	V		-
	37 Amplitude LQ	3	approx. 2.5	V		-
	38 PZF 2	3	0-5	V		-
	39 Signal amplitude P _{EF}	3	0-5	V		-
	40 ---	3	-	V		-
	41 Flow velocity	4	v	m/s		-

Function Switches

Pos- ition	Channel (switch)			
	a	b	c	d
0	Access levels 0: Display level 1: User level 2: Service level	Failure signal (Alarm at 21.8mA) 0: OFF 1: ON	Counter reset 0: OFF 1: Reset	0: Default
1	Auto-adaptation (cap. selection) 0: OFF 1: ON	Auto-adaptation (filter selection) 0: OFF 1: ON	Filter bandwidth 0: 20dB (normal) 1: 40dB	0: Default
2	Amplifier guidance (in stages K22) 0: OFF 1: ON	Hardware reset 0: OFF 1: ON	Amplifier bandwidth at Qmax 0: normal 1: wide	Low flow suppression 0: OFF 1: ON
3	Filter guidance (Output filter fo) 0: OFF 1: ON	Open measurement range 0: OFF 1: ON	0: Default	Current pulse output (general.) 0: OFF (for HART comm.) 1: ON
4	LCD test 0: OFF 1: ON	Filter guidance (Output filter fu) 0: OFF 1: ON	0: Default	Auto-adaptation (Selection of the number of stages) 0 to 6
5	Current simulation (value of K15) 0: OFF 1: ON	Quick start 0: OFF 1: ON	Current pulse output with HART comm. (only at 150ms) 0: OFF 1: ON	NAMUR output 0: OFF 1: Original frequency 2: Scaled pulses 3-8: Simulation values *
6	Alignment PWM / Quarz 0: OFF 1: ON	---	Pulse simulation (NAMUR output) 0: OFF 1: ON	Pule width select 0: 150ms/3Hz 1: 100ms/5Hz 2: 45ms/11Hz 3: 28ms/18Hz

* Simulation values NAMUR output

Frequency simulation	3: 28Hz 4: 112.5Hz 5: 900Hz 6: 1800Hz 7: 3600Hz
Pulse simulation	8: Pulse width

5.3 Description of Functions

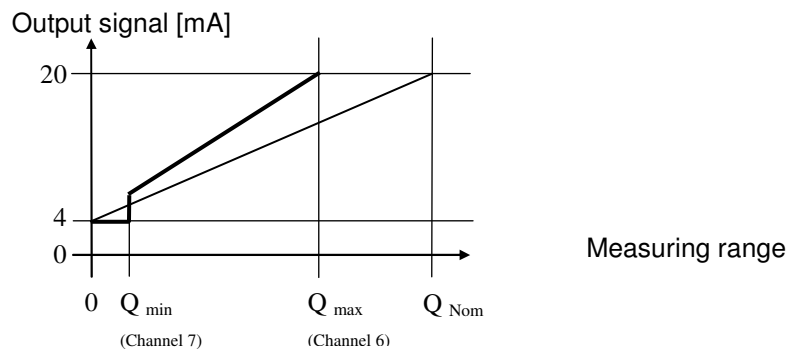
5.3.1 Analog Operation (Channel 16)

The analog output signal of 4 to 20 mA can be freely assigned to the desired measuring range within the flow rate limits of the corresponding counter quantity.

There are two analog operating modes:

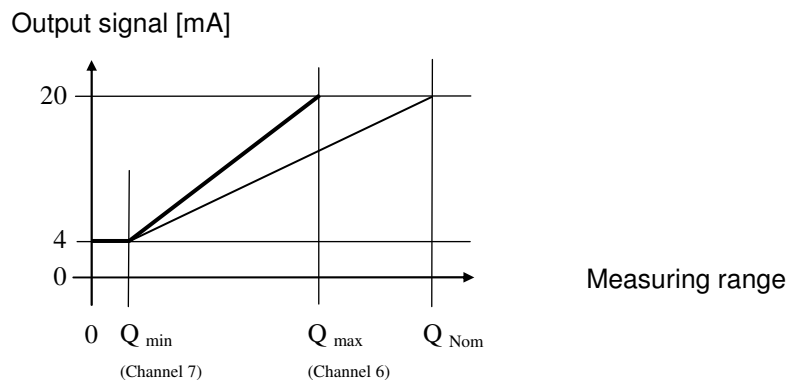
5.3.1.1 Output Signal Proportional to Upper Range Value

4 mA = Q = 0
(Mode 0)



5.3.1.2 Output Signal Proportional to Measuring Range Span

4 mA = Q min
(Mode 3)



This setting is made with Channel 16

Mode	0	3
Operating mode	4 mA = Q = 0	4 mA = Q min

5.3.1.3 Damping of Output Current (Channel 14)

With channel 14 you set the damping ratio. The setting range is between 1 (no damping) and 200 (highest degree of damping = time constant 200 s).

5.3.1.4 Current Simulation (Channel 15)

With the current simulation you can set different output currents between 4 and 22 mA.

How to proceed:

- 1 Switch on current simulation with function switch A 5 (enter 1).
- 2 Set the desired output current with Channel 15 (enter value in mA).
- 3 Switch off current simulation with function switch A 5 (enter 0).

5.4.1 Pulse Operation (Counter operation)

5.4.1.1 Two-Wire Current Pulse Output (Channel 16)

For volume measurements you can switch the two-wire circuit to pulse operation.

Current pulses between 4 mA = low and 20 mA = high will be supplied as the output signal.

You can select between a scalable pulse output or a pulse output of original vortex pulses.

This setting is made with Channel 16:

Mode	1	2
Operating mode	Scaled pulses	Original vortex pulses

In addition to this setting, the analog/digital jumper on the front of the electronics must be set to digital operation.

Note!

HART communication is not permitted during pulse operation. For HART configuration, the pulse output must be switched off temporarily (function switch D 3, enter 1).

5.4.1.2 Two-Wire Current Pulse Output with HART Function

In the analog operating mode (Mode 0) a pulse output with simultaneous two-wire HART communication can be utilised.

Pulse signal specs.

Current pulses: Current Low ≤ 9 mA
 Current High ≥ 12 mA
 Pulse width 150 ms

For this, the function switch (C5 is set to 1 [on]). The analog/digital jumper on the front of the electronics must be set to analog operation. The pulse width for the pulses which are output must be set to 150 ms.

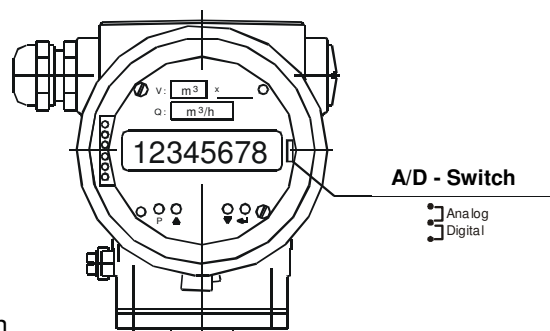


Fig. 8 Analog-Digital Switch

5.4.1.3 NAMUR – Pulses

In addition to the 2-wire connection, a separate pulse output in accordance with NAMUR is available. The additional NAMUR output can either be set to original vortex pulses (e.g. for test purposes, if a high pulse resolution is necessary) or to scaled pulses with selectable meter factor and pulse width.

This setting is made with function switch D 5:

Setting	0	1	2
Function	Pulses off	Original vortex pulses	Scaled pulses

5.4.1.4 Pulse Value Factor (Channel 9)

Through the pulse value factor you can set the meter factor of the output pulses and the counter increment.

You can set the following decadic steps for the pulse value factor (Channel 9):

0.01	0.1	1	10	100
------	-----	---	----	-----

Example:

If the pulse value factor is 10 then the following applies

a) for the pulse output:

$$1 \text{ pulse} = 10 \text{ units (e.g. } 10 \text{ m}^3\text{), depending on the selected unit}$$

b) for the meter's display (with pulse ratio factor 1, see Chapter 6.2.4):

$$1 \text{ counter increment} = 10 \text{ units (e.g. } 10 \text{ m}^3\text{)}$$

If the pulse output is scaled, it must be ensured that the maximum frequency of the pulse output, depending on the selected pulse width, is not exceeded (see Table 5.6.1.5).

The smallest permissible pulse value factor Z is given by

$$Z \geq \frac{Q_{\max}}{f_{\max}}$$

Q_{\max} : max. flow rate [selected unit/seconds]

f_{\max} : max. frequency of the scaled pulse output (depending on the selected pulse width, see Table 5.6.1.5)

Example 1:

$$Q_{\max} = 400 \text{ m}^3 / \text{h} = 0.111 \text{ m}^3 / \text{s}$$

$$\text{Pulse width } 150 \text{ ms} = f_{\max} = 3 \text{ Hz}$$

$$Z \geq 0.111 / 3 = 0.037 \text{ m}^3$$

thus a smallest pulse value of $Z = 0.1$ can be selected, i.e. 1 pulse = 0.1 m³

Example 2:

$$Q_{\max} = 60,000 \text{ kg / h} = 16.67 \text{ kg / sec}$$

$$\text{Pulse width } 28 \text{ ms} = f_{\max} = 18 \text{ Hz}$$

$$Z \geq 16.67 / 18 = 0.926 \text{ kg}$$

⇒ smallest pulse value possible $Z = 1$ (or higher), i.e. 1 pulse = 1 kg

5.4.1.5 Pulse Width

(Function switch D 6)

The output pulse width can be selected according to the following table:

Setting	0	1	2	3
Pulse width	150 ms	100 ms	45 ms	28 ms
Max. frequency	3 Hz	5 Hz	11 Hz	18 Hz

5.4.1.6 Pulse Simulation**NAMUR pulse output**

With pulse simulation, various output pulses can be simulated. During a simulation, the transmission of the vortex signals is stopped.

1. Switch on pulse simulation with function switch C 6.
2. Select output pulses with D 5.

Setting	3	4	5	6	7	8 (pulse width according to D 6)			
Value [Hz]	28	112,5	900	1800	3600	3	5	11	18

Two-wire current pulses

Pulse simulation has an effect only on the scaled pulse output. Pulse width must be set to 150 ms (3Hz).

5.5.1 Low-Flow Cutoff

Below the programmed lower range value (Qmin), the output variable is set to zero (0) , i.e., the current output decreases to 4 mA for analog operation, and the pulse output is switched off for pulse operation.

Low-flow cutoff can be deactivated for special applications (e.g. pulse output for test purposes).

Set function switch D 2 to 0 (OFF).

5.6 Unit Selection (Channel 10)

5.6.1 Standard Units

You can select the desired unit with Channel 10.

Setting	0	1	2	3	4	5	6	7	8	9	10
Unit	l/s	l/min	l/h	m ³ /s	m ³ /min	m ³ /h	ft ³ /s	ft ³ /min	ft ³ /h	Impgal/s	Impgal/min

Setting	11	12	13	14	15	16	17
Unit	Impgal/h	gal/s	gal/min	gal/h	USER	kg/h	t/h

5.6.2 Special Units

In order to activate this function, you must set channel 10 to the USER unit (15). With channel 29 or 30 you can set the factors with which the process values can be converted to any unit or display value. If the default setting is active, the conversion factors in channel 29 and 30 are set to 1, i.e., the value is displayed in the previously valid units (e.g. in m³ or m³/h).

The value range of these factors is: $0.0001 \leq F \leq 99990$.

Caution: The counter must first be configured for the required operating volume measuring range with the units [m³/h].

The basic units (m³ or m³/h) are to be included for the calculation of the conversion factors to the desired display value.

Note: The maximum flow rate must not exceed a number of 99990.

5.6.2.1 Flow Rate Factor (Channel 29)

With channel 29 you set the conversion factors for the flow rate display.

Example 1: Converting standard volume flow rate for the unit [m³/h]

Flow rate factor

$$F_D = \frac{\rho_B}{\rho_N}$$

ρ_B : Operating density, e.g. $\rho_B = 7.00 \text{ kg/m}^3$
 ρ_N : Standard density, e.g. $\rho_N = 1.28 \text{ kg/m}^3$

$$F_D = \frac{7.00}{1.28} = 5.4689$$

Example 2: Converting the standard volume flow rate for the unit [yard³ / d], for $\rho_B / \rho_N = 6.0000$

Flow rate factor

$$F_D = \frac{\rho_B}{\rho_N} \cdot \frac{x}{y}$$

x: Conversion factor for volume unit
 e.g. $1 \text{ m}^3 = 1.30795 \text{ yard}^3$, i.e.
x= 1.30795

y: Conversion factor for time unit
 e.g. $1 \text{ h} = 1 / 24 \text{ d}$, i.e.
y= 1 / 24

thus the flow rate factor is calculated

$$F_D = 6 \cdot \frac{1.30795}{1/24} = 188.34$$

5.6.2.2 Volume Factor (Channel 30)

With Channel 30 you set the conversion factors for volume measurement.

Example 1: Conversion to standard volume for the unit [m³]

Volume factor

$$F_V = \frac{\rho_B}{\rho_N}$$

$$F_V = \frac{7.00}{1.28} = 5.4689$$

Example 2: Conversion to standard volume for the unit [yard³], where $\rho_B / \rho_N = 6.000$

Volume factor:

$$F_V = \frac{\rho_B}{\rho_N} \cdot x$$

$$F_V = 6 \times 1.30795 = 7.8477$$

x: Conversion factor for volume unit
e.g. $1 \text{ m}^3 = 1.30795 \text{ yard}^3$, d. h.
x = 1,30795

5.6.2.3 Pulse Ratio Factor (Channel 31)

With the factor (F_I) that can be set with Channel 31 the magnitude of counter increment (display) $W_{\text{zähl}}$ and pulse output (NAMUR and current pulses) W_{puls} can be set differently. For the standard setting, the factor is 1, i.e. the significance of counter increment and pulse output are identical.

$$W_{\text{puls}} = F_I \cdot W_{\text{zähl}}$$

Example:

$F_I = 10$ Results in a transformation of the scaled pulse output to ten times as much as the counter increment, i.e., the pulse output is ten times faster.

Caution: Observe the limit value for the maximum frequency of the pulse output (see Table 4.4).

$F_I = 0.1$ Results in a reduction of the scaled pulse output to one 10^{th} of the counter increment, i.e., the pulse output is ten times slower.

The value range of this factor is: $0.0001 \leq \text{factor} \leq 99999$

5.7.1 Device Data (Channel 8)

The k factor is a device constant that is calculated for each device through a factory calibration.

The value is entered in [pulses/l] for DN 15 to DN 80

in [pulses/m³] for DN 100 to DN 250

The measuring range table lists the mean values for the individual nominal size.

5.8.1 Nominal Size (Channel 11)

When you exchange the electronics, the nominal size must be set as follows:

Entry		015	025	040	050	080	100	150	200	250
DN	DIN	15	25	40	50	80	100	150	200	250
	In.	½	1	1 ½	2	3	4	6	8	10

5.9.1 Medium (Channel 12)

The medium determines the limit values of the measuring range (see measuring range table) and the automatic gain and filter settings of the electronics.

The setting is made in three classes.

Setting	0	1	2
Medium	Gas	Liquid	Steam

5.10.1 Density (Channel 13)

Here you must enter the (minimum) operating density of the medium. With this density, apart from the effect on the automatic amplifier and filter setting, the conversion is performed with respect to the standard mass unit that may have been selected.

The operating density must be entered in the unit [kg/m³].

5.11.1 Amplifier Limiter (Channel 22)

The optimum settings for the intended operating conditions are factory-preset.

However, periodic pulsations or vibrations of the pipe may generate unwanted signals, and a flow rate is displayed in spite of the fact that the flow rate is zero.

With the setting in Channel 22 you can limit the amplifier gain in selectable levels. Thus the device can be adjusted to the corresponding operating conditions.

A lower gain stage means lower gain. In this way the sensitivity to disturbances can be reduced when the flow rate is zero.

Stage	0	1	2	3	4	5	6
Gain factor	1	2	4	8	16	32	64

Caution: If the stage number is too low, the measuring range may be restricted at low flow rates. During operation the currently active gains stage is displayed, not the limit.

5.12.1 Sensor Comparing Function (Channel 34)

This function contains a calibration value for suppressing inferences. It serves the purposes of symmetry alignment between the two sensor circuits. When changing the preamplifier stage, the sensor comparing function should also be aligned.

5.13.1 Status Information (Channel 17)

Channel 17 displays the current status of the device. If a fault is detected, it will be displayed in the status channel. You clear the fault by acknowledging it by shifting. If the same message is displayed again, it is valid.

Code no.	Meaning
001	Changing the operating data after automatic setting
002	Performing settings manually
003	Flow rate below Q_{min}
004	Flow rate is in low-flow operation (90 to 100%)
005	Incorrect filter
006	No valid data in the EEPROM
010	Incorrect data in Channel 0
011	Incorrect data in Channel 1
↓	↓
046	Incorrect data in Channel 35
050	Data entry via interface does not function properly
051	Incorrect measuring range
060	Incorrect unit of measurement
100	Storage error (alarm 21.8 mA)

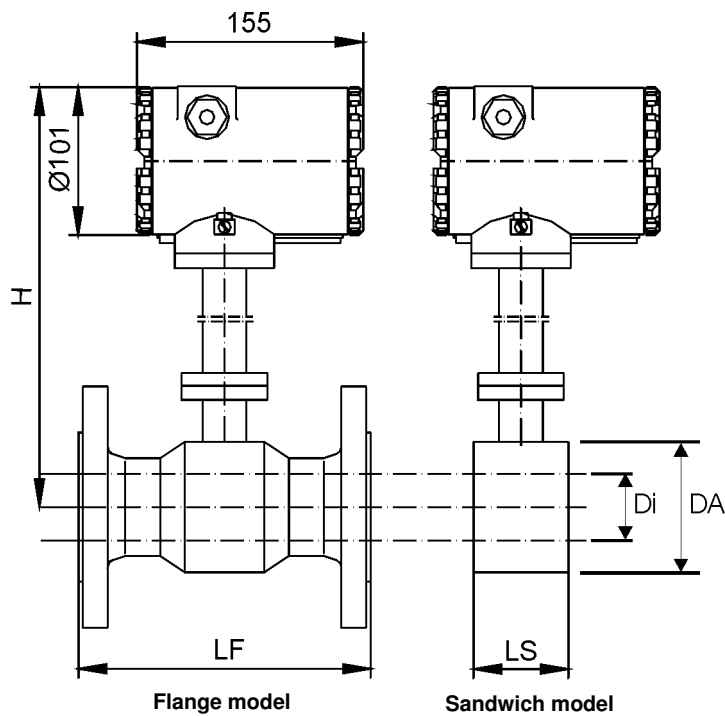
6. Dimensions and Weights

6.1 Dimensions of the Various Models

6.1.1 Types/Dimensions

Pressure rating: PN 40 / Class 300						
DN		DA [mm]	Di [mm]	H [mm]	LS [mm] Sandwich	LF [mm] Flange
DIN	Inches					
15	½"	45	16	335	65	200
25	1"	67	27	335	65	200
40	1½"	85	41,5	340	65	200
50	2"	105	53	340	65	200
80	3"	136	80	350	65	200
100	4"	164	103	365	65	250
150	6"	220	154	400	90	300
200	8"	275	202	430	120	300
250	10"	330	253	460	140	380
300	12"	380	303	500	160	450

Other nominal widths upon request.



6.1.2 Weight

DN		Weight sandwich model	Weight flange model
DIN	ANSI	[kg]	[kg]
15	1/2"	2.0	4.5
25	1"	2.5	7
40	1 1/2"	3.0	10
50	2"	3.5	12
80	3"	9.5	26
100	4"	12.5	38
150	6"	20.5	
200	8"	30.5	
250	10"	40.5	
300	12"		

7. Specifications

7.1 Material

Sensor: stainless steel 1.4571 and 3.1B certificate
Housing with bluff body: stainless steel 1.4404 and 3.1B certificate
Seals: viton and graphite
(other materials upon request)

Electronics housing: die-cast aluminum

7.2 Process Connection

Sandwich: DN 15 to DN 300 and PN 10 to PN 40 (PN 100 upon request)
1/2" – 12" Class 150 and Class 300 (Class 600 upon request)
Flange: DN 15 to DN 300 and PN 10 to PN 40 (PN 100 upon request)
1/2" – 12" Class 150 and Class 300 (Class 600 upon request)

Larger nominal sizes and pressure stages upon request.

7.3 Environmental Conditions

Exposure of the electronics housing to sudden temperature changes must be avoided.

7.3.1 Ambient Temperature

-40° C to +70° C
Operation of the LC display is only ensured down to -10° C.

7.3.2 Storage Temperature

-40° C to +70° C

7.3.3 Climatic Category

Class DIEC 654-1

7.3.4 Degree of Protection

IP67 IEC 529 / EN 60529

7.3.5 Electromagnetic Compatibility

According to EMC guidelines 89/336/EEG, EN 50081 Part 1 and 2; EN 50082 Part 1 and 2 as well as NAMUR NE 21

Electromagnetic compatibility is only ensured when the electronics housing is closed.
When the electronics housing is open, the device may malfunction due to electromagnetic signal pickup (see Chapter 4.2 Connecting the "trikon").

7.4 Process Conditions

7.4.1 Media Temperature

-40 °C to 260 °C standard

up to 450 °C for custom versions

The temperature categories for category II media are given in the following table:

Temperature category	Media temperature	Ambient temperature range (electronics housing)
T1	up to +450 °C	-40 °C < Ta < + 70 °C
T2	up to +300 °C	-40 °C < Ta < + 70 °C
T3	up to +200 °C	-40 °C < Ta < + 70 °C
T4	up to +135 °C	-40 °C < Ta < + 70 °C
T5	up to +100 °C	-40 °C < Ta < + 70 °C
T6	up to +85 °C	-40 °C < Ta < + 70 °C

The temperature categories for category I/II media are given in the following table:

Temperature category	Media temperature	Ambient temperature range (electronics housing)
T4	-20 °C to +60 °C	-40 °C < Ta < + 70 °C
T5	-20 °C to +60 °C	-40 °C < Ta < + 70 °C
T6	-20 °C to +60 °C	-40 °C < Ta < + 70 °C

The process pressure for the media must, in the case of category I media, range between 0.8 bar and 1.1 bar.

7.4.2 State of Aggregation

Liquids, gases, and steam

7.4.3 Viscosity

Viscosity limits the linear measuring range for which the error limits (measured error) are valid.

Linearity limit $Q_{Lin} = 2.826 \cdot D \cdot Re \cdot \nu$

D = inside diameter [mm]

Re = Reynolds Number (limit value)

ν = dynamic viscosity [m²/s]

7.4.4 Media Pressure Limit

Depends on the design.

7.4.5 Flow Rate Limit

The max. velocity for gases and steam is about 80 m/s, and for liquids about 10 m/s. In the case of liquids the cavitation limit needs to be observed in addition.

For gases having a density $< 1.2 \text{ kg/m}^3$ the lower limit for the measurements can be calculated from

$$Q_{\min} = 1.1 \frac{Q_L}{\sqrt{\rho_B}}$$

Q_L = lower flow limit for air [m^3/h] (see Table 2.4)

The limit for linearity will depend on viscosity and is for a Reynolds number of $\text{Re}=20000$ (see 7.4.3).

This can be checked using the following equation: $Q_{Lin} = 2.826 \cdot D \cdot \text{Re} \cdot \nu$

7.4.6 Pressure Loss

Pressure loss can be calculated using the following equation:

$$\Delta p = 1400 \cdot \rho_B \cdot \frac{Q_B^2}{DN^4} \text{ [mbar]}$$

where

ρ_B	=	Operating density [kg/m^3]
Q_B	=	Operating flow rate [m^3/h]
DN	=	Nominal size [mm].

The results obtained will represent a rough estimate.

Example: DN 100 ; $Q_B = 230 \text{ m}^3/\text{h}$; $\rho_B = 7.1 \text{ kg/m}^3$
(saturated steam at 14 bar)

$$\Delta p = 1400 \times 7.1 \times 230^2 / 100^4 = 5.25 \text{ mbar}$$

Remark: see Annex

- Table for saturated steam
- Approximate calculation for determining operating density
- Gas constants (R_i table)

7.4.7 Cavitation in Liquids

When running measurements on liquids, the effect of cavitation within the vortex meter **must** be avoided. For this it must be ensured by design that the pressure downstream of the vortex meter can **not** drop below the vapour pressure for the liquid used.

At an approximate back pressure given below, cavitation can be avoided.

$$p_{\min} \geq 2.8 \times \Delta p + 1.3 \times p_v$$

where

p_{\min}	=	Minimum pressure in the pipe
Δp	=	Pressure loss
		$\Delta p = 1400 \times \rho_B \times (Q_B^2 / DN^4)$
p_v	=	Vapour pressure of the liquid being measured under operating conditions

Example: DN 80; water of 20 °C ; $\rightarrow Q = 108 \text{ m}^3/\text{h}$
 $\Delta p_{VTX 2} = 1400 \times 998.3 \times (108^2 / 80^4) \rightarrow \Delta p_{VTX 2} = 398 \text{ mbar}$
 $p_v = 0.02337 \text{ bar}$ (from VDO table for water vapour)
 $\Rightarrow p_{\min} \geq 2.8 \times 0.40 + 1.3 \times 0.02337 = 1.15 \text{ bar}$

Thus for a VTX 2 DN 80 (water, 20 °C, $Q_B = 108 \text{ m}^3/\text{h}$) a pressure over 1.15 bar is required so as to avoid cavitation.

Remark: see table in the Annex: density and vapour pressure of water.

7.5 Characteristic Values

7.5.1 Reference Conditions

According to IEC 770: 20 °C, 65% relative humidity, 101.3 kPa

7.5.2 Measured Error (Accuracy)

	$Re \geq 20,000$	$10,000 < Re \leq 20,000$
Gas/steam	$\pm 1.0\%$ of measured value	$\pm 1.0\%$ of upper value (for $Re = 20,000$)
Liquids	$\pm 1.0\%$ of measured value	$\pm 1.0\%$ of upper value (for $Re = 20,000$)

7.5.3 Repeatability

$\pm 0.15\%$ of measured value

7.6 Certificates Approvals and Standards

CE mark

EMC in accordance with directive 89/336/EEG, EN 50081 Part 1 and 2; EN 50082 Part 1 and 2, as well as NAMUR NE 21

Type of protection for the housing: EN 60529

NAMUR: EN 60947-5-6

Equipment safety: EN 61010

Pressurised equipment directive: 97/23/EG

8. "trikon" Configuration Data Sheet

Channel No.	Denomination	Setting															
	Customer																
	Order no.																
	Serial no.																
	Tag no. (meas. point no.)																
	Type (model code)																
	Nominal flow rate	Liquid m ³ /h						Gas m ³ /h									
	Nominal pressure																
6	Upper range value	Q _{max}	<input type="checkbox"/> m ³ /h						<input type="checkbox"/>								
7	Lower range value	Q _{min}	<input type="checkbox"/> m ³ /h						<input type="checkbox"/>								
8	k factor	up to DN 80 pulses/l						from DN 100 pulses/m ³									
9	Pulse value factor Z	<input type="checkbox"/> 0.01			<input type="checkbox"/> 0.1			<input type="checkbox"/> 1			<input type="checkbox"/> 10			<input type="checkbox"/> 100			
	Meter factor	1 pulse \cong						1 counter increment \cong									
10	Units	<input type="checkbox"/> 0	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5	<input type="checkbox"/> 6	<input type="checkbox"/> 7	<input type="checkbox"/> 8	<input type="checkbox"/> 9						
		l/s	l/min	l/h	m ³ /s	m ³ /min	m ³ /h	ft ³ /s	ft ³ /min	ft ³ /h	Impgal/s						
		<input type="checkbox"/> 10	<input type="checkbox"/> 11	<input type="checkbox"/> 12	<input type="checkbox"/> 13	<input type="checkbox"/> 14	<input type="checkbox"/> 15	<input type="checkbox"/> 16	<input type="checkbox"/> 17								
		Impgal/min		Impgal/h		gal/s		gal/min		gal/h		USER		kg/h		t/h	
11	Nominal size DN	<input type="checkbox"/> 015	<input type="checkbox"/> 025	<input type="checkbox"/> 040	<input type="checkbox"/> 050	<input type="checkbox"/> 080	<input type="checkbox"/> 100	<input type="checkbox"/> 150	<input type="checkbox"/> 200	<input type="checkbox"/> 250	<input type="checkbox"/> 300						
		<input type="checkbox"/> DIN	15	25	40	50	80	100	150	200	250	300					
		<input type="checkbox"/> In.	1/2"	1"	1 1/2"	2"	3"	4"	6"	8"	10"	12"					
12	Medium	<input type="checkbox"/> 0 Gas				<input type="checkbox"/> 1 Liquid				<input type="checkbox"/> 2 Steam							
13	Operating density	$\rho_{min} =$ <input type="checkbox"/> kg/m ³															
14	Damping	(from 1 to 200)															
16	2-wire current loop	<input type="checkbox"/> 0 4mA = 0				<input type="checkbox"/> 3 4mA = Q _{min}				<input type="checkbox"/> 2 Original vortex pulses				<input type="checkbox"/> 1 Scaled pulses			
29	Flow rate factor	F _D				<input type="checkbox"/> 1				<input type="checkbox"/> .							
30	Volume factor	F _V				<input type="checkbox"/> 1				<input type="checkbox"/> .							
31	Pulse ratio factor	F _J				<input type="checkbox"/> 1				<input type="checkbox"/> .							
D5	NAMUR pulse output	<input type="checkbox"/> 0 OFF				<input type="checkbox"/> 1 Original vortex frequ.				<input type="checkbox"/> 2 Scaled pulses							
D5	Pulse width	<input type="checkbox"/> 0 150ms/3Hz				<input type="checkbox"/> 1 100ms/5Hz				<input type="checkbox"/> 2 45ms/11Hz				<input type="checkbox"/> 3 28ms/18Hz			
	E-series no./date																

9. Approximate Calculation for Determining the Density of Gas and Superheated Steam

$$\rho = p / (R_i \times T) \quad [\text{kg/m}^3]$$

where	ρ	=	Operating density	[kg/m ³]
	p	=	Operating pressure (abs.)	[N/m ²] resp. [Pa]
	R_i	=	Specific gas constant	[Nm/kgK]
	T	=	Operating temperature	[K]

Example: Medium air; 5 bar; $t = 20^\circ\text{C}$

$$\rho = (5 \times 10^5) / (260 \times 293.15)$$

$$\rho = 6.56 \text{ kg/m}^3$$

Specific gas constant R_i	
Type of gas	R_i in [Nm/(kg x K)]
Argon (Ar)	208
Acetylene (C ₂ H ₂)	320
Ammonia (NH ₃)	488
Helium (He)	2078
Carbondioxide (CO ₂)	189
Carbonmonoxide (CO)	297
Air	287
Methane (CH ₄)	519
Oxygen (O ₂)	260
Nitrogen (N ₂)	297
Water vapour (H ₂ O)	462
Hydrogen (H ₂)	4158

Table 12: Specific gas constants of some gases

10. Tables

State quantities of water and steam

Pressure (abs.)	Boiling temperature	Steam density
p [bar]	t _s [°C]	ρ _s [kg/m³]
0.30	69.12	0.1912
0.40	75.89	0.2504
0.60	85.95	0.3660
0.80	93.51	0.4792
1.0	99.63	0.5905
1.2	104.81	0.7003
1.6	131.32	0.9167
2.0	120.23	1.130
3.0	133.54	1.652
3.4	137.86	1.858
4.0	143.63	2.164
4.5	147.92	2.417
5.0	151.85	2.669
6.0	158.84	3.170
7.0	164.06	3.667
8.0	170.41	4.161
9.0	175.36	4.654
10	179.88	5.114
11	184.06	5.634
12	187.96	6.123
13	191.60	6.612
14	195.04	7.100
15	198.28	7.580
16	201.37	8.077
17	204.30	8.566
18	207.11	9.056
19	209.79	9.546
20	212.37	10.04
22	217.24	11.02
26	226.03	13.00
30	233.84	15.00
34	240.88	17.02
38	247.31	19.07
40	250.33	20.11

Density and vapour pressure of water

T °C	P _d bar	ρ kg/m ³	T °C	P _d bar	ρ kg/m ³	T °C	P _d bar	ρ kg/m ³
0	0.00611	999.8	56	0.16511	985.2	122	2.1145	941.2
1	0.00657	999.9	57	0.17313	984.6	124	2.2504	939.6
2	0.00706	999.9	58	0.18147	984.2	126	2.3933	937.9
3	0.00758	999.9	59	0.19016	983.7	128	2.5435	936.2
4	0.00813	1000	60	0.19920	983.2	130	2.7013	934.6
5	0.00872	1000				132	2.8670	932.8
6	0.00935	1000	61	0.2086	982.6	134	3.041	931.1
7	0.01001	999.9	62	0.2184	982.1	136	3.223	929.4
8	0.01072	999.9	63	0.2286	981.6	138	3.414	927.6
9	0.01147	999.8	64	0.2391	981.1	140	3.614	925.8
10	0.01227	999.7	65	0.2501	980.5			
			66	0.2615	979.9	145	4.155	921.4
11	0.01312	999.7	67	0.2733	979.3	150	4.760	916.8
12	0.01401	999.6	68	0.2856	978.8	155	5.433	912.1
13	0.01497	999.4	69	0.2984	978.2	160	6.181	907.3
14	0.01597	999.3	70	0.3116	977.7	165	7.008	902.4
15	0.01704	999.2				170	7.920	897.3
16	0.01817	999.0	71	0.3253	977.0	175	8.924	892.1
17	0.01936	998.8	72	0.3396	976.5	180	10.027	886.9
18	0.02062	998.7	73	0.3543	976.0	185	11.233	881.5
19	0.02196	998.5	74	0.3696	975.3	190	12.551	876.0
20	0.02337	998.3	75	0.3855	974.8	195	13.987	870.4
			76	0.4019	974.1	200	15.55	864.7
21	0.02485	998.1	77	0.4189	973.5			
22	0.02642	997.8	78	0.4365	972.9	205	17.243	858.8
23	0.02808	997.6	79	0.4547	972.3	210	19.077	852.8
24	0.02982	997.4	80	0.4736	971.6	215	21.060	846.7
25	0.03166	997.1				220	23.198	840.3
26	0.03360	996.8	81	0.4931	971.0	225	25.501	833.9
27	0.03564	996.6	82	0.5133	970.4	230	27.976	827.3
28	0.03778	996.3	83	0.5342	969.7	235	30.632	820.5
29	0.04004	996.0	84	0.5557	969.1	240	33.478	813.6
30	0.04241	995.7	85	0.5780	968.4	245	36.523	806.5
			86	0.6011	967.8	250	39.776	799.2
31	0.04491	995.4	87	0.6249	967.1			
32	0.04753	995.1	88	0.6495	966.5	255	43.246	791.6
33	0.05029	994.7	89	0.6749	965.8	260	46.943	783.9
34	0.05318	994.4	90	0.7011	965.2	265	50.877	775.9
35	0.05622	994.0				270	55.058	767.8
36	0.05940	993.7	91	0.7281	964.4	275	59.496	759.3
37	0.06274	993.3	92	0.7561	963.8	280	64.202	750.5
38	0.06624	993.0	93	0.7849	963.0	285	69.186	741.5
39	0.06991	992.7	94	0.8146	962.4	290	74.461	732.1
40	0.07375	992.3	95	0.8453	961.6	295	80.037	722.3
			96	0.8769	961.0	300	85.927	712.2
41	0.07777	991.9	97	0.9094	960.2			
42	0.08198	991.5	98	0.9430	959.6	305	92.144	701.7
43	0.08639	991.1	99	0.9776	958.6	310	98.700	690.6
44	0.09100	990.7	100	1.0133	958.1	315	105.61	679.1
45	0.09582	990.2				320	112.89	666.9
46	0.10086	989.8	102	1.0878	956.7	325	120.56	654.1
47	0.10612	989.4	104	1.1668	955.2	330	128.63	640.4
48	0.11162	988.9	106	1.2504	953.7			
49	0.11736	988.4	108	1.3390	952.2	340	146.05	610.2
50	0.12335	988.0	110	1.4327	950.7	350	165.35	574.3
			112	1.5316	949.1	360	186.75	527.5
51	0.12961	987.6	114	1.6362	947.6	370	210.54	451.8
52	0.13613	987.1	116	1.7465	946.0	374.15	221.2	315.4
53	0.14293	986.6	118	1.8628	944.5			
54	0.15002	986.2	120	1.9854	942.9			
55	0.15741	985.7						

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